# AIR QUALITY

# NORTHWESTERN ONTARIO

# ANNUAL REPORT, 1991

SEPTEMBER 1992

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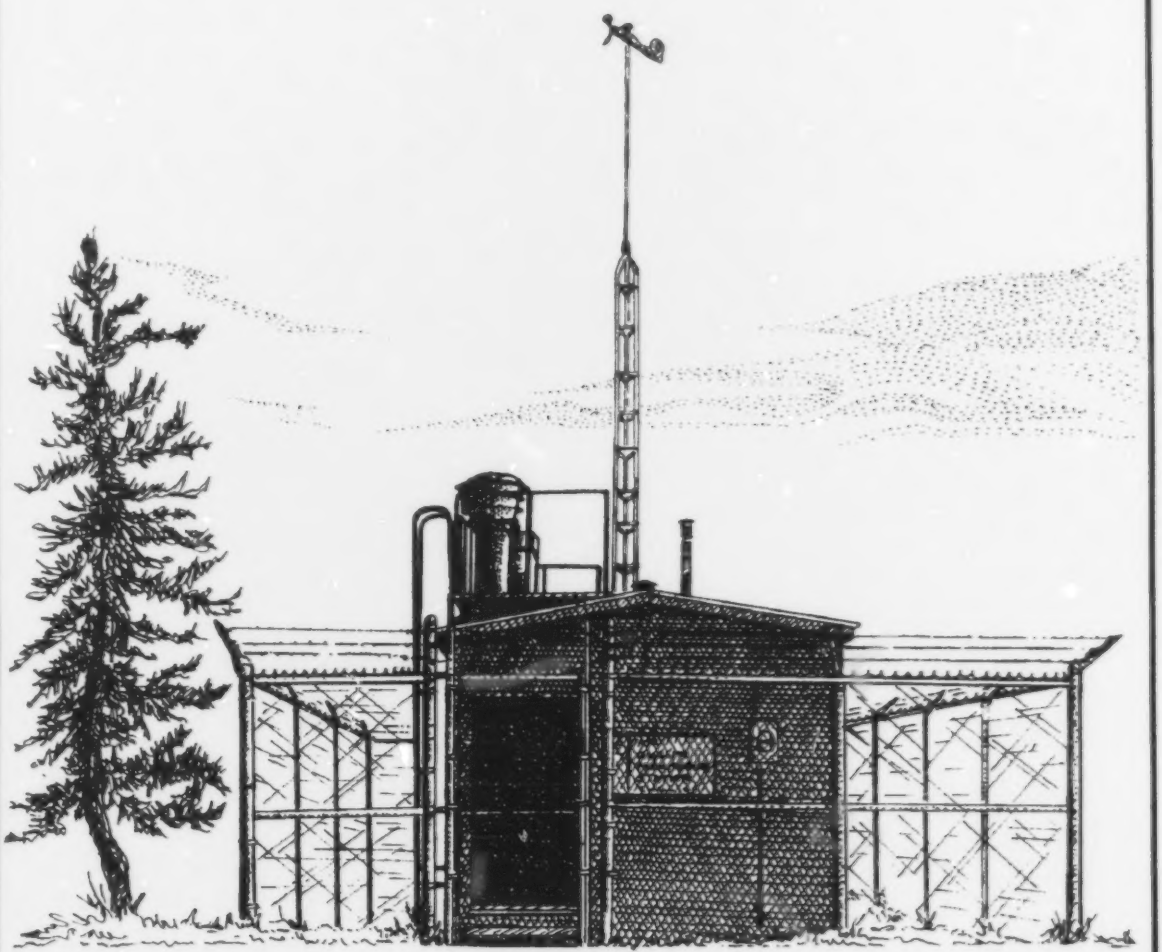

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# AIR QUALITY

# NORTHWESTERN ONTARIO
# ANNUAL REPORT, 1991

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## TABLE OF CONTENTS


SUMMARY 1

**INTRODUCTION** 4

**1.0 PURPOSE OF MONITORING PROGRAM** 4

**2.0 POLLUTANTS AND THEIR MEASUREMENT** 5

2.1 Particulate Matter 5
2.2 Gaseous Pollutants 6
2.2.1 Carbon Monoxide (CO) 6
2.2.2 Nitrogen Oxides ($N0_x$) 7
2.2.3 Ozone ($O_3$) 7
2.2.4 Sulphur Dioxide ($S0_2$) 8
2.2.5 Total Reduced Sulphur (TRS) 8
2.2.6 Organic Compounds 8
2.3 Miscellaneous 9

**RESULTS** 10

**3.0 ATIKOKAN** 10

3.1 Ontario Hydro Generating Station 10

**4.0 BALMERTOWN** 10

4.1 Arsenic 11
4.2 Sulphur Dioxide 11

**5.0 DRYDEN** 12

5.1 Odour Levels 12
5.2 Particulate Matter 12

**6.0 FORT FRANCES** 13

6.1 Vegetation Effects 13
6.2 Particulate Matter 14
6.3 Odour Levels 14

**7.0 KENORA** 15

7.1 Particulate Matter 15

**8.0 MARATHON** 16

8.1 Particulate Matter 16
8.2 Odour Levels 16

**9.0 RED ROCK** 17

9.1 Odour Levels 17

**10.0 SCHREIBER** 17

10.1 Particulate Matter 18

**11.0 TERRACE BAY** 18

12.1 Odour Levels 18

**12.0 THUNDER BAY** 19

12.1 Particulate Matter 19
12.1.1 Dustfall 19
12.1.2 Suspended Particulate Matter(TSP) and Soiling Index 20
12.1.3 Inhalable Particulate Matter (IPM) 20

12.2 Gaseous Pollutants 20
12.2.1 Carbon Monoxide (CO), Nitrogen Dioxide ($NO_2$) and Ozone ($O_3$) 20
12.2.2 Sulphur Dioxide ($SO_2$) 21
12.2.3 Total Reduced Sulphur (TRS) 21
12.2.4 Organic Compounds 21

12.3 Air Quality Index (AQI) 22

12.4 Special Studies 22
12.4.1 Thunder Bay Terminals Limited 22

**REPORTS ISSUED IN 1991** 23

**REFERENCES** 25

**FIGURES AND TABLES** 28-49

## SUMMARY

This report presents results of the Ministry's air quality assessment program for 1991 in northwestern Ontario. It includes data from 10 communities where long-term monitoring is conducted.

### ATIKOKAN

During 1991, there were no exceedences of air quality objectives for sulphur dioxide, nitrogen dioxide or ozone near Ontario Hydro's lignite-fuelled power plant at Atikokan. Because no exceedences of any air quality objective had occurred for 5 years of plant operation, monitoring ceased at the end of 1991.

### BALMERTOWN

Arsenic persisted at elevated concentrations in vegetation on company property near two gold mines, but was near normal in the adjoining townsite. Arsenic levels decreased from 1990 to 1991. A special survey showed that airborne arsenic on and off Dickenson Mines property substantially met air quality objectives.

During the growing season (May to September), hourly average sulphur dioxide exceeded the acceptable limit only three times, compared with 34 exceedences in 1990. Minor vegetation injury caused by sulphur dioxide was noted on the Campbell Mine property, but not in the townsite. Campbell's ore concentrate roaster, which was the principal sulphur dioxide source, was shut down in mid July. The Ministry removed its sulphur dioxide monitor in October.

### DRYDEN

Odour levels in Dryden continued the excellent record of recent years. There were no exceedences of the Ontario guideline for total reduced sulphur (TRS) during 1991.

A special dustfall survey has so far not found evidence of a wood-fines fallout problem.

### FORT FRANCES

In 1991, there was no visible off-property vegetation damage caused by air emissions from the local kraft pulp mill. Foliar sodium levels were well below the contaminant guideline at all sampling sites around the mill, indicating good control of particulate emissions (saltcake) from the mill's recovery furnace.

Average dustfall also showed improvement over 1990, continuing a trend which began a few years ago. Wood-fines still sometimes contributed significantly to elevated dustfall. Average suspended particulate concentrations met Ministry objectives and were the lowest since monitoring began in 1976.

Odour levels also improved from 1990 to 1991. At the Ministry's main monitoring site in Fort Frances, TRS guideline exceedences declined from 493 in 1990, to 251 in 1991. Further improvement in community air quality is expected in 1992.

**KENORA**

Substantial compliance with Ontario dustfall objectives was again achieved in Kenora in 1991. Since particulate fallout from the local pulp mill no longer appears to be a problem, dustfall measurement will cease in 1992.

**MARATHON**

There was general compliance with dustfall objectives near a wood-chip storage area at a local kraft pulp mill.

Average odour levels near the mill improved during the year, continuing a trend began in 1989; there were 24 exceedences of the TRS guideline in 1991. A control program is in place which will require compliance with the TRS guideline by October 1993.

**RED ROCK**

Air quality with respect to odours improved from 1990 to 1991, but there were still 40 exceedences of the provincial TRS guideline. Some of the problems leading to high TRS readings have been identified and resolved.

**SCHREIBER**

The latest data have shown substantial compliance with air quality objectives near a transfer site for base-metal ore concentrates on CP Rail property in Schreiber. A new concentrate handling system, introduced in late 1991, is expected to resolve any outstanding concerns about dust emissions from the transfer site.

**TERRACE BAY**

Air quality in Terrace Bay in 1991 was similar to 1990. An abatement plan is being prepared to address emissions from the spills collection pond at the local kraft pulp mill; this pond appears to be the main source of TRS impacting community air quality. A special air quality survey is scheduled for 1992 to confirm the location of specific TRS sources.

**THUNDER BAY**

Dustfall at two monitoring sites near a local pulp mill (Canadian Pacific Forest Products Ltd.) fully met Ontario objectives in 1992. Suspended particulate matter in the city also met the annual provincial objective, as did soiling index levels.

Concentrations of carbon monoxide, nitrogen dioxide, ozone and sulphur dioxide consistently met Ministry objectives in Thunder Bay in 1991. The TRS guideline near a kraft pulp mill (Canadian Pacific Forest Products) was exceeded 19 times. During the year, Thunder Bay's Air Quality Index was "very good" or "good" for all but 10 hours, when it was "moderate" due to TRS (7 hours) or suspended particles (3 hours).

Airborne dust levels were satisfactory in residential areas near Thunder Bay Terminals Limited.

# INTRODUCTION

## 1.0 PURPOSE OF MONITORING PROGRAM

The Ontario Ministry of the Environment assesses air quality throughout the province. Monitoring networks record outdoor concentrations of pollutants that may adversely affect human health, animal life, vegetation, and the use and enjoyment of property. These surveys document compliance with air quality objectives, and determine long-term air quality trends. Pollution sources are identified and the results of pollution control measures are assessed.

In northwestern Ontario, air quality surveys first began in 1963, to measure airborne dust in the City of Thunder Bay. In 1991, the regional monitoring network covered 9 communities, with more than 50 monitoring devices (Tables 1 and 2). More than 20 different pollutants were measured, plus meteorological parameters. Ontario Hydro also operated air quality networks in Thunder Bay and Atikokan.

Data from air quality and meteorological instruments are supplemented by vegetation, soil and snow sampling studies, and by predictions of pollutant levels with mathematical models.

Monitoring in the region is mostly conducted in urban areas and near industrial sources of air pollution (eg. mines, pulp and paper mills). Therefore, air quality problems described in this report are not typical of the region, where air quality is generally excellent.

Acid rain is a major environmental issue in eastern North America and in parts of Europe. Ontario, through its Acidic Precipitation in Ontario Study, is assessing the effects of acid fallout throughout the province. The Ministry's Northwestern Region has participated in this program by operating a precipitation sampling network and by conducting lake sampling surveys. The findings of these studies have been reported elsewhere.

The installation of a telemetry system in 1986 was a major enhancement of the region's air quality monitoring program. This system greatly increases the speed with which air quality data are received. It permits the Ministry to obtain immediate readings from any continuous monitor. From early June, 1988, an Air Quality Index (AQI) has been issued eight times daily for Thunder Bay and other cities in Ontario. The Thunder Bay AQI is based on readings for six pollutants: carbon monoxide, ozone, nitrogen dioxide, suspended particles (soiling index), sulphur dioxide, and total reduced sulphur. In September 1989, one of the Fort Frances monitoring stations was designated a AQI site, to publish levels of total reduced sulphur. Measurement of suspended particles was added at this station in September, 1991.

## 2.0 POLLUTANTS AND THEIR MEASUREMENT

### 2.1 Particulate Matter

There are many man-made and natural sources of airborne particulate matter. Typical man-made sources in northwestern Ontario are forest product industries and mining operations. Wind-blown particles from stored materials and roadways are examples of secondary sources. Particulate matter may also be emitted from agricultural activity, forest fires, volcanoes, and dust storms. Depending on particle size and chemical makeup, particulate matter may harm health and vegetation, may affect visibility, and may cause local nuisance problems. In Ontario, particulate matter is measured as dustfall, total suspended particulate matter (TSP), inhalable particulate matter (IPM), and soiling index.

Dustfall is particulate matter that settles out from the air by gravity. Open-top containers (dustfall jars) are exposed for 30-day periods and the collected matter is weighed.[1] The monthly air quality objective (maximum acceptable limit) for dustfall is 7 $g/m^2/30$ d (grams per square metre during 30 days). The annual objective is 4.6 $g/m^2/30$ d. Dustfall estimates the fallout of particulate matter from local sources, including dust from construction or from vehicles. It is usually not considered to be a health-related pollutant, but may cause a significant nuisance because of soiling effects.

Suspended particulate matter comprises particles of small size which remain entrained in the air for long periods. This material may come from local or distant sources. It is measured with a high-volume sampler for a 24-hour period every sixth day.[2] The difference in the weight of a fibreglass filter before and after exposure determines the quantity of particulate matter collected.

The air quality objective is 120 $\mu g/m^3$ (micrograms per cubic meter of air sampled) averaged over 24 hours, and 60 $\mu g/m^3$, annual geometric mean.

Inhalable particulate matter comprises particles smaller than 10 $\mu m$ (micrometres) in diameter. It is measured with a standard high-volume sampler fitted with a size-selective inlet. Samples are collected on a quartz filter exposed for a 24-hour period every sixth day. An Ontario air quality objective for inhalable particulate matter is being developed.

Soiling index is a measure of the soiling or darkening properties of very small airborne particles and is expressed as coefficient of haze (COH). It is related to the concentration of respirable particulate matter. A measured volume of air passes through a paper tape which moves through an automated sampling unit to produce a reading every hour. The reduction of light transmitted through the tape is expressed as coefficient of haze (COH) per 1,000 linear feet of air sampled. The Ontario objective is 1.0 COH, 24-hour average, and 0.5 COH, annual average.

## 2.2 Gaseous Pollutants

### 2.2.1 Carbon Monoxide (CO)

Carbon monoxide is a colourless, odourless gas. Its primary source (about 80%) is motor vehicles. A secondary source is fossil fuel combustion. As the number of vehicles in northwestern Ontario is small relative to other parts of the province, carbon monoxide is not a problem pollutant in this region. Elevated concentrations of carbon monoxide cause well-known health effects. The maximum acceptable level in Ontario is 30 ppm (parts of

carbon monoxide per million parts of air), 1-hour average, and 13 ppm, 8-hour average. This pollutant is measured with a continuous analyzer[3] at two locations in Thunder Bay.

### 2.2.2 Nitrogen Oxides ($NO_x$)

Nitric oxide (NO) and nitrogen dioxide ($NO_2$) are together termed nitrogen oxides ($NO_x$). Both NO and $NO_2$ may be emitted from natural and man-made sources. High-temperature fuel combustion, which occurs in vehicle engines and thermal power plants, is the main man-made emission source. At concentrations measured in ambient air, NO has no known adverse effects. NO may, however, oxidize to $NO_2$ which, in turn, may adversely affect health and visibility. $NO_2$ also reacts with hydrocarbons in sunlight to form ozone. It may also combine with water to form nitric acid, a component of acid rain. In northwestern Ontario, nitrogen oxides are monitored with a continuous analyzer[4] at one location in Thunder Bay. The air quality objectives for $NO_2$ in Ontario are 0.2 ppm, 1-hour average, and 0.1 ppm, daily average.

### 2.2.3 Ozone ($O_3$)

Ozone occurs naturally and beneficially in the upper atmosphere. Near the ground, it is a product of reactions between nitrogen oxides and hydrocarbons in the presence of sunlight. If present at high concentrations, it may affect health and vegetation. Since ozone-forming compounds are not emitted in large amounts in northwestern Ontario, elevated ozone readings, if present, would suggest long-range transport from outside the region. The Ministry measures ozone with continuous analyzers[5] at two sites in northwestern Ontario and one in northern Minnesota. The Minnesota monitor is located at an air quality research site near the town of Ely. The Ontario air quality objective for ozone is 0.08 ppm, averaged over one hour.

### 2.2.4 Sulphur Dioxide ($SO_2$)

Sulphur dioxide is one of the world's major atmospheric pollutants and has many well-known effects on health, vegetation and property. It is also one of the main contributors to acid rain. In northwestern Ontario, the principal $SO_2$ sources are small compared to those in some other parts of the province. The main regional emitters of $SO_2$ are, in approximate descending order of importance, Ontario Hydro generating stations (Thunder Bay and Atikokan), sulphite pulp mills, gold ore roasting, and industrial boilers. The Ministry measures sulphur dioxide with continuous analyzers[6] at two locations in the region. There are three air quality objectives for this pollutant: 0.25 ppm, hourly average; 0.10 ppm, 24-hour average; and 0.02 ppm, annual average.

### 2.2.5 Total Reduced Sulphur (TRS)

Total reduced sulphur comprises a group of sulphur-containing gases found in emissions from kraft pulp mills, which are the sole significant TRS sources in the region. At very low concentrations, TRS results in offensive odours. Higher levels may cause temporary discomfort to sensitive individuals. In Ontario, a guideline of 27 ppb (parts of TRS, expressed as hydrogen sulphide, per billion parts of air), averaged over one hour, is used as an air quality objective near kraft pulp mills. TRS is measured with continuous analyzers[7] at 11 sites in northwestern Ontario.

### 2.2.6 Organic Compounds

The Ministry is expanding its small network for measuring organic compounds. The compound groups included in this network are dioxins/furans, VOCs (volatile organic compounds) and PAHs (polynuclear aromatic hydrocarbons). These pollutants are often called "air toxics", and are of special interest as possible health risks in urban areas. The VOC group in the Ministry's air monitoring program currently includes 35 compounds. There are 33 PAH compounds analyzed.

In northwestern Ontario in 1991, the Ministry operated one VOC and one PAH monitor, both in Thunder Bay. Expansion of organics measurement in the region will occur as resources permit.

## 2.3 Miscellaneous

The occurrence and effects of some of the foregoing pollutants, plus others, may be assessed by vegetation injury and by determining contaminant levels in vegetation, soil and snow. Standard Ministry procedures,[8,9,10] are followed in collecting and analyzing these types of samples. Arsenic, chloride, fluoride,[11] sulphur and heavy metals are typical pollutants examined this way. Their levels in a study area are compared with normal background values at sites unaffected by pollution. Contaminant guidelines developed by the Ministry for vegetation, soil and snow are used in this report. The guidelines are based on the upper limit of "normal" elemental concentrations across the province. Exceedence of a guideline may indicate a contamination problem. However, it is not a violation of Ministry regulations, nor does it necessarily imply health or environmental effects.

Most analyses for vegetation, soil and snow, are carried out at the Ministry's Thunder Bay laboratory. The Ministry's Toronto laboratory analyses inhalable particulate matter, plus sulphur and halides (chloride, fluoride) in vegetation and soil. The Toronto laboratory also analyses VOC (volatile organic compounds) and PAH (polynuclear aromatic hydrocarbons). A private laboratory carries out most of the dustfall and suspended particulate matter tests.

The Ministry's Air Resources Branch produces computer printouts of all air quality and meteorological data for the region.

# RESULTS

## 3.0 ATIKOKAN

### 3.1 Ontario Hydro Generating Station

In 1981, the Ministry and Ontario Hydro began air quality studies around a lignite-fired generating station under construction near Atikokan. Ontario Hydro operated the air quality monitoring network and the Ministry collected precipitation, vegetation, soil, and snow samples at several sites (Figure 1).

By late 1985, when the 200-megawatt plant went into service, at least three years of background data had been collected. A summary report for the pre-operational terrestrial and atmospheric deposition studies was issued in 1986.[12]

During years of plant operation from 1986 to 1991, Ontario Hydro's environmental quality compliance reports showed that there were no exceedences of Ontario's air quality objectives for sulphur dioxide, ozone, or nitrogen dioxide. Reports on atmospheric deposition and terrestrial data revealed no significant changes from the pre-operational period.[13,14] The terrestrial studies concluded in 1988; re-sampling is scheduled for 1992. During 1990 and 1991, deposition monitoring was reduced from three sites to one (Fernberg Road in northern Minnesota). The Ministry's deposition monitoring program at Fernberg Road will terminate in September, 1992. Ontario Hydro terminated its Atikokan air quality monitoring program at the end of 1991.

## 4.0 BALMERTOWN

Since 1971, the Ministry has conducted air quality surveys near two gold mines in Balmertown. For many years, the Campbell Mine (Placer Dome Inc.) and the Arthur W. White Mine (Dickenson Mines Limited), emitted significant amounts of airborne arsenic trioxide and sulphur dioxide from ore roaster stacks. In the mid-1970's, both mines reduced

arsenic emissions by more than 95%. In early 1980, Dickenson shut down its roaster. The Campbell Mine suspended concentrate roasting in July, 1991.

## 4.1 Arsenic

In 1991, arsenic concentrations in leaves of trembling aspen trees at 17 sites near the mines (Figure 2) remained elevated on mine properties but were near normal in the townsite. Elevated arsenic near the mines is ascribed to localized fugitive emissions from arsenic-containing wastes or from concentrates. Stack emissions may also have contributed to arsenic fallout prior to shutdown of the roaster in July. Table 3 compares arsenic readings for the past 5 years at selected sites on and off mine properties. Average foliar arsenic levels in the survey area declined from 1990 to 1991.

Table 4 presents arsenic data for 1987-91 from planted roadside trees in the townsite. The 1991 decrease in arsenic shown in Table 3 was also evident in Table 4. Even though current stack emissions of arsenic have ceased, past contamination of surface soil in the area may result in ongoing elevated arsenic in the local environment. For this reason, Balmertown residents have been advised to thoroughly wash vegetables from their gardens.

A special survey on and off the property of Dickenson Mines Limited revealed substantial compliance with air quality objectives for arsenic and heavy metals.[15]

## 4.2 Sulphur Dioxide

In 1991, the Ministry's Balmertown monitor recorded 33 hourly $SO_2$ readings and two, 24-hour $SO_2$ averages which exceeded acceptable levels. The maximum hourly average was 0.61 ppm, more than double the Ontario objective of 0.25 ppm. The annual average (0.004 ppm) was well below the acceptable limit of 0.020 ppm. Scattered evidence of light $SO_2$

injury to white birch foliage was noted on Campbell Mine property, but not in the adjacent townsite.

During the growing season (May to September), $SO_2$ was above the acceptable hourly limit only three times, compared with 34 in 1990. Table 5 summarizes the data for the past 5 years. The large reduction in exceedences from 1990 to 1991 was largely due to the shutdown of the Campbell ore roaster in mid July. Without this change, the number of elevated $SO_2$ readings in 1991 would probably have been similar to previous years. No measurable sulphur dioxide was recorded after the roaster shutdown. $SO_2$ monitoring in the townsite terminated in early October.

## 5.0 DRYDEN

For several years, the Ministry has monitored air quality near a bleached kraft pulp mill in Dryden. Abatement action, process changes, and mill modernization have resolved most of the air quality concerns of the 1970s and early 1980s. Currently, the Ministry monitors odour levels in the town centre. In addition, two dustfall measurement sites were established in June, 1991, in response to concerns about fallout of wood-fines.

### 5.1 Odour Levels

Offensive odours caused by reduced sulphur compounds are monitored with a continuous TRS analyzer in central Dryden (station 61027, Figure 3). As Table 6 shows, odour levels in 1991 were satisfactory throughout the year. There were no exceedences of the provincial guideline for TRS.

### 5.2 Particulate Matter

At monitoring stations 61022 and 61028 (locations shown in Figure 3), 12 of 14 monthly dustfall samples met the Ministry criterion (7 $g/m^2$/30 days). Wood-fines did not cause the two exceedences recorded. Unless frequent occurrences of high dustfall are found, this survey will terminate in 1992.

## 6.0 FORT FRANCES

During its first years of operation, emissions from a bleached kraft pulp mill in Fort Frances resulted in particulate fallout and odour problems in a nearby residential area. In the late 1970s, some emission reductions were achieved. In 1980, a Control Order was issued for further pollution controls. The mill also created a "buffer zone" through purchase of adjacent residential land.

Air quality studies in Fort Frances have been conducted regularly since 1972 near the Canadian mill, and periodically since 1974 around a similar nearby plant owned by the parent corporation on the U.S. side of the border (Figure 4).

### 6.1 Vegetation Effects

In 1991, there was no visible air pollution injury to vegetation inside or outside the buffer zone around the Fort Frances mill. The condition of trees which had suffered damage in past years was mostly unchanged from previous years. Dead branches had been recently removed from some of the most severely damaged trees. Sodium in tree foliage was very low in 1991, as it was in 1990. Table 7 compares the data from 1987, 1989 and 1991 with sodium levels in 1980, the year selected as typical for average conditions from 1975 to 1986. The improvement is obvious as shown by the data in the table as well as the graph in Figure 5. Reduced emissions of saltcake from the Fort Frances mill are credited for this trend.

## 6.2 Particulate Matter

Dustfall results for 1991 are summarized in Table 8. The annual air quality objective for dustfall was met at four of the six monitoring sites off mill property. At the two monitoring stations on mill property, dustfall moderately exceeded the objective. All but one of the nine exceedences of the monthly dustfall objective off mill property occurred during the spring or summer; wood fibres accounted for about 5 to 50% of total dustfall when these high readings were recorded. However road dust and biological matter (eg. pollen, insect parts) were also sometimes present in significant amounts. A comparison of average dustfall during recent years (Table 9) shows a steady trend of decline. The low level of saltcake in dustfall mirrored the sodium data for vegetation.

In 1991, annual average total suspended particulate matter (TSP) at the monitoring site near the mill (station 62035) was 43 $\mu g/m^3$, well below the provincial objective of 60 $\mu g/m^3$ and the lowest since monitoring began in 1976. Five of the fifty-three daily readings at this site exceeded the 24-hour objective. Highest levels occurred during calm conditions, or with south to southwest wind when the monitor was downwind of the mill. The annual average TSP at the Fort Frances cemetery (station 62032) was 23 $\mu g/m^3$, which was also, by a narrow margin, the lowest value yet recorded at this site. There were no exceedences of the daily objective at station 62032.

Levels of suspended particles (soiling index), measured on a real-time basis at the AQI station (62030), met the provincial objective during the period (September to December) when data were available.

### 6.3 Odour Levels

The number of exceedences of the TRS guideline declined sharply from 1990 to 1991 at monitoring site 62030 near the Boise Cascade Canada mill, but increased at station 62032 nearest Boise's U.S. mill (Table 10). Modest improvements were recorded at the two other TRS monitoring sites (62047 on Eighth Street, 62051 at La Verendrye Hospital). Further improvement may be expected at the Eighth Street site when a new condensate stripper system in the Fort Frances mill is properly operational.

Data from the monitoring station near the Civic Centre (station 62030) has been published daily as an Air Quality Index (AQI) starting November 15, 1989. During 1991, there were 950 hours of "moderate" air quality (compared with 850 hours in 1990), and 251 hours of "poor" air quality (493 hours in 1990). At all other times, the AQI was "very good" or "good". TRS was solely responsible for all occurrences of moderate or poor air quality.

To reduce TRS emissions, a condensate stripper system was installed at the Fort Frances mill in 1991. This project is experiencing start-up problems. Changes in operation of the mill's tall oil plant were implemented in 1991 to reduce TRS emissions from that source. Recent emission testing revealed that the mill's effluent pumphouse was a significant TRS source; Boise Cascade has been directed to reduce emissions from the pumphouse. This action, plus resolution of problems with the condensate stripper, should lead to further air quality improvement in 1992.

## 7.0 KENORA

For many years, the Ministry has monitored air quality near Boise Cascade Canada's sulphite pulp mill in Kenora. The current monitoring program comprises dustfall measurements at four locations (Figure 7).

### 7.1 Particulate Matter

In 1991, only one of the four monitoring sites (station 61007, just north of the mill) experienced average annual dustfall slightly above the air quality objective. A similar result was found in 1990. Eight of forty-eight monthly samples exceeded the objective. All these elevated readings occurred in spring and summer, when road dust and biological matter were the greatest contributors to high dustfall. Substances attributable to mill operations (eg.wood-fines, wood char) accounted for less than 15% of dustfall.

Average dustfall in Kenora has been generally within acceptable limits for the past few years with no indication of significant impact of Boise Cascade operations are dustfall levels. The 1990 installation of a new precipitator for the mill's power boilers contributed to this achievement. As dustfall levels in Kenora are now satisfactory, further measurement will be terminated in 1992.

## 8.0 MARATHON

The Ministry currently maintains one air quality monitoring station in Marathon (Figure 8). A continuous analyzer at this station monitors odour levels near the kraft pulp mill operated by James River-Marathon, Ltd. The company also has dustfall jars at four sites to measure fallout of particulate matter near a storage area for wood chips.

### 8.1 Particulate Matter

The fallout of wood-fines from wood-chip piles near the pulp mill ("wood storage area", Figure 10) has been studied by the company and by the Ministry.[17] For 1991, the company's data revealed that only 2 of 48 dustfall samples exceeded the maximum acceptable limit at sites off company property. The two elevated readings were only moderately above the objective.

### 8.2 Odour Levels

Average annual TRS (Table 12) declined from 1990 to 1991, continuing the trend begun in 1989. There were 24 TRS guideline exceedences in 1991. A recently-issued Certificate of Approval requires James-River to comply with the TRS guideline by October, 1993. Two TRS emission tests well be carried out before that date.

Other pollution control developments at James-River in 1991 included the installation of scrubbers on the mill's bleach plant, and the replacement of coal-fired power boilers with oil-fired boilers.

## 9.0 RED ROCK

The Ministry operates an air quality analyzer in the Town of Red Rock to measure odours near a kraft pulp mill operated by Domtar Inc. (Figure 9).

### 9.1 Odour Levels

There were 40 exceedences of the TRS guideline in 1991, well down from the 80 recorded in 1990 (Table 13). Some of the exceedences occurred during scheduled or unscheduled shutdowns of the primary lime kiln and during episodes of venting from digesters. The digester problem has now been resolved. Equipping the back-up lime kiln to treat odorous gases is a possible future step to eliminate the last significant TRS source at the mill.

## 10.0 SCHREIBER

In response to concerns about dust emissions from an ore concentrate transfer facility on CP Rail property, the Ministry has been conducting air quality studies since 1988. The zinc and copper concentrates are produced at the Minnova Inc. base metal mine, 20 km northwest of Schreiber.

### 10.1 Particulate Matter

While the first Ministry studies at Schreiber showed that fallout of dust from the transfer site resulted in elevated airborne metals, the latest published data[16] revealed that levels of cadmium, copper and zinc were acceptable up to early 1991. Complete 1991 suspended particulate matter data (unpublished) show that there was only one exceedence of the 24-hour objective at the two monitoring sites; metal levels were consistently within acceptable limits. Results from the 1991 moss exposure tests are under review.

In late 1991, a completely new system of shipping and handling the ore concentrate was put in place. This system is expected to resolve any outstanding concerns. Ministry testing will continue. A report will be prepared for 1991 air sampling and moss exposure studies, plus results from an early 1992 snow sampling survey.

## 11.0 TERRACE BAY

The Ministry's monitoring program in Terrace Bay is directed toward measurement of odour levels in the townsite and near a new secondary treatment system (lagoon) near the Kimberly-Clark Canada Inc. kraft pulp mill (Figure 10).

### 11.1 Odour Levels

In the townsite (station 63090), air quality changed little from 1990 to 1991, as Table 14 shows. There were 59 TRS guideline exceedences at our monitoring location.

At monitoring station 63093 near the lagoon, there were 379 exceedences of the TRS guideline, up from 204 in 1990. The two pollution roses in Figure 10 show that in 1991 the spills pond area northwest of the lagoon was the strongest source of TRS. Similar results were found in 1990. These findings indicated that the lagoon itself was a minor TRS source. Moss exposure tests in 1989 and 1990[17] showed that the lagoon was not a significant source of airborne particulate matter.

Kimberly-Clark is preparing a plan to address TRS emissions from the spills pond. Confirmation of the plan will occur after a special air quality survey with mobile monitoring equipment is carried out in August, 1992.

## 11.0 THUNDER BAY

In 1991, the Ministry operated a six-station air quality monitoring network in Thunder Bay. The locations of these sites, plus those operated by Ontario Hydro, are shown in Figure 11. One station, 63200, records all continuously measured pollutants. These include sulphur dioxide, ozone, carbon monoxide, nitrogen oxides, particulate matter (soiling index) and total reduced sulphur. An hourly Air Quality Index (AQI) is issued for this site. Three of the Ministry's Thunder Bay stations (63005, 63022 and 63200) are part of Environment Canada's National Air Pollution Surveillance network. Ontario Hydro operated five sulphur dioxide monitors in the city at the beginning of the year, and reduced this network to three monitors during the year (stations 63041, 63044 and 63048. The following sections summarize 1991 air quality data from Thunder Bay.

## 12.1 Particulate Matter

### 12.1.1 Dustfall

A data summary appears in Table 15 for the two sites where dustfall measurements were carried out in 1991. There were no exceedences of the monthly dustfall objective at either location, and the annual objective was also met.

### 12.1.2 Suspended Particulate Matter (TSP) and Soiling Index

Concentrations of total suspended particulate matter were fully acceptable at the four Thunder Bay monitoring sites in 1991 (Table 16). Both daily and annual objectives were met. Samples from the two city-centre stations (stations 63005 and 63022) had acceptable concentrations of heavy metals, including lead. Levels of sulphate and nitrate, which are influenced by long-range transport, varied considerably.

At station 63200, soiling index also met the daily and annual air quality objectives.

### 12.1.3 Inhalable Particulate Matter (IPM)

Sampling for inhalable particulate matter (IPM) began at station 63200 (Walsh and James Street) in July, 1989. In 1991, IPM ranged from 4 to 46 $\mu g/m^3$, with an arithmetic mean of 19 $\mu g/m^3$. At present, Ontario is developing an objective for IPM. In the United States, standards range from 50 to 150 $\mu g/m^3$ for single samples, and from 30 to 50 $\mu g/m^3$ for annual averages.

## 12.2 Gaseous Pollutants

### 12.2.1 Carbon Monoxide (CO), Nitrogen Dioxide ($NO_2$) and Ozone ($O_3$)

Throughout the year, carbon monoxide was well below the maximum acceptable limit for 1-hour and 8-hour averages at Thunder Bay monitoring stations. Nitrogen dioxide met the 1-hour and 24-hour objectives. Ozone met the provincial 1-hour objective of 0.08 ppm at all times in Thunder Bay and at a nearby rural site. Ozone, a long-range transport pollutant, is not currently considered a problem in northwestern Ontario. Summary figures for carbon monoxide, nitrogen dioxide and ozone are in Table 17.

### 12.2.2 Sulphur Dioxide ($SO_2$)

The principal industrial sources of sulphur dioxide in Thunder Bay are a 310-megawatt, lignite-fired, electric generating station and three pulp and paper mills. Collectively, these sources are relatively small; total $SO_2$ emissions in Thunder Bay are less than 100 metric tons per day. Except for one hour at one site, the network of six $SO_2$ monitors (five belonging to Ontario Hydro and one owned by the Ministry) showed full compliance for all $SO_2$ air quality objectives in 1991 (Table 18). On March 8, the hourly air quality objective (0.25 ppm) was exceeded for one hour at Ontario Hydro's Mt. McKay monitoring station (station 63041). An hourly average of 0.29 ppm was recorded on that date; wind direction data implicated Canadian Pacific Forest Products Limited as the probable source of the $SO_2$.

### 12.2.3 Total Reduced Sulphur (TRS)

At the Ministry's Montreal Street monitoring site (station 63046), there were 19 exceedences of the TRS guideline in 1991 (Table 19). There were no exceedences of the guideline at the Thunder Bay Air Quality Index station (James and Walsh).

In 1992, there should be a decrease in TRS emissions from Canadian Pacific Forest Products as a result the start-up, in February, 1992, of a secondary treatment system at the company's pulp mill.

### 12.2.4 Organic Compounds

The Ministry operates a sampler for PAH (polynuclear aromatic hydrocarbon) compounds in Thunder Bay north to obtain data on general urban PAH levels and to assess PAH concentrations downwind of Northern Wood Preservers Inc. Northern Wood uses creosote and, occasionally, pentachlorophenol wood preservatives. Both these substances contain PAH compounds, some of which are suspected causes of cancer. For 1991, no existing standards or guidelines for PAH compounds were exceeded at the Thunder Bay monitoring site.

Urban concentrations of VOCs (volatile organic compounds), have been measured at the Thunder Bay Air Quality Index station since October, 1990. Toxic organic compounds such as benzene, xylene, and toluene are included in this survey. VOC levels in 1991 were found to be very low, and well within acceptable limits.

## 12.3 Air Quality Index (AQI)

An hourly Air Quality Index (AQI) was determined for the six pollutants continuously monitored at station 63200 (Walsh and James Street). During 1991, the AQI was very good or good for all but 10 hours when it deteriorated to the moderate category. The pollutant responsible for 7 hours of moderate AQI was TRS; the other three moderate readings were due to suspended particles. The maximum AQI during the year was 36.

## 12.4 Special Studies

### 12.4.1 Thunder Bay Terminals Limited

A report on monitoring near Thunder Bay Terminals Limited[18] showed that provincial air quality objectives were substantially met in 1991. Western coal and potash are the main products handled at Thunder Bay Terminals. There has been no increase in dust levels at off-property monitoring sites since coal shipments began in 1978.

## REPORTS ISSUED IN 1991

The following list includes reports released as technical memoranda during 1991. For each document, a brief summary is included. Items already listed under "References" for this report (see pages 27-29) are excluded.

1. Air quality, northwestern Ontario, 1989.

   Results of the Ministry's air quality assessment program for 1988 in northwestern Ontario are presented.

2. Air quality, northwestern Ontario, 1990.

   Results of the Ministry's 1990 air quality assessment program in northwestern Ontario are presented.

3. An air pollution episode in Thunder Bay.

   Describes an incident in November, 1990, when vehicle emissions resulted in elevated levels of suspended particles.

4. Snow sampling survey near McKenzie Forest Products Inc., Hudson, 1991.

   Fallout of wood-fines and charred wood particles exceeded contaminant guidelines off company property. An abatement plans being developed.

5. Air quality, Kenora District, quarterly review.

   Quarterly data summaries were issued for Kenora District for the periods April - June and July - September, 1991.

6. Ait quality, Thunder Bay District, quarterly review.

   Quarterly data summaries were issued for Thunder Bay District for the periods April - June and July - September,1991.

## REFERENCES

1. Ontario Ministry of the Environment. 1984. Method for the sampling and determination of atmospheric dustfall. Report AMP-142. Air Resources Branch.

2. Ontario Ministry of the Environment. 1979. Method of high volume sampling and determination of total suspended particulate matter in ambient air. Report AMP-101. Air Resources Branch.

3. Ontario Ministry of the Environment. 1981. Method for the sampling and determination of carbon monoxide in ambient air by non-dispersive infrared spectrometry. Report AMP-123. Air Resources Branch.

4. Ontario Ministry of the Environment. 1981. Method for continuous sampling and determination of nitrogen dioxide and nitric oxide in ambient air by chemiluminescence. Report AMP-121. Air Resources Branch.

5. Ontario Ministry of the Environment. 1981. Method for the continuous sampling and determination of ozone in ambient air by chemiluminescence. Report AMP-120. Air Resources Branch.

6. Ontario Ministry of the Environment. 1981. Method for the continuous sampling and determination of sulphur dioxide in ambient air by fluorescence. Report AMP-118. Air Resources Branch.

7. Ontario Ministry of the Environment. 1981. Method for the continuous sampling and determination of total reduced sulphur in ambient air by fluorescence. Report AMP-130. Air Resources Branch.

8. Ontario Ministry of the Environment. 1983. Field investigation manual. Phytotoxicology Section, Air Resources Branch.

9. Ontario Ministry of the Environment. 1989. A guide to the collection and submission of samples for laboratory analysis, 6th edition. Laboratory Services Branch.

10. Ontario Ministry of the Environment. 1981. Outlines of analytical methods. Laboratory Services Branch.

11. Ontario Ministry of the Environment. 1979. Method for sampling and determination of fluoride in vegetation. Report AMP-111. Air Resources Branch.

12. Racette, D. J. and H. D. Griffin. 1986. Pre-operational terrestrial and atmospheric deposition studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1981 to 1985. Ontario Ministry of the Environment.

13. Racette, D. J. and H. D. Griffin. 1989. Terrestrial and atmospheric deposition studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1986. Ontario Ministry of the Environment.

14. Racette, D. J. and H. D. Griffin. 1991. Terrestrial and atmospheric deposition studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1987-89. Ontario Ministry of the Environment.

15. Griffin, H.D. 1991. Airborne arsenic near Dickenson Mines, Balmertown, 1989-90. Ontario Ministry of the Environment.

16. Racette, D. J. and H. D. Griffin. 1991. Air quality studies near an ore concentrate trans-shipment site, Schreiber, 1990-91. Ontario Ministry of the Environment.

17. Racette D.J. and H.D. Griffin 1991. Air quality study near an aerated stabilization basin, Kimberly-Clark Canada Inc., Terrace Bay, 1989-90. Ontario Ministry of the Environment.

18. Griffin, H. D. 1992. Air quality assessment, Thunder Bay Terminals Limited, Thunder Bay, 1991. Ontario Ministry of the Environment.

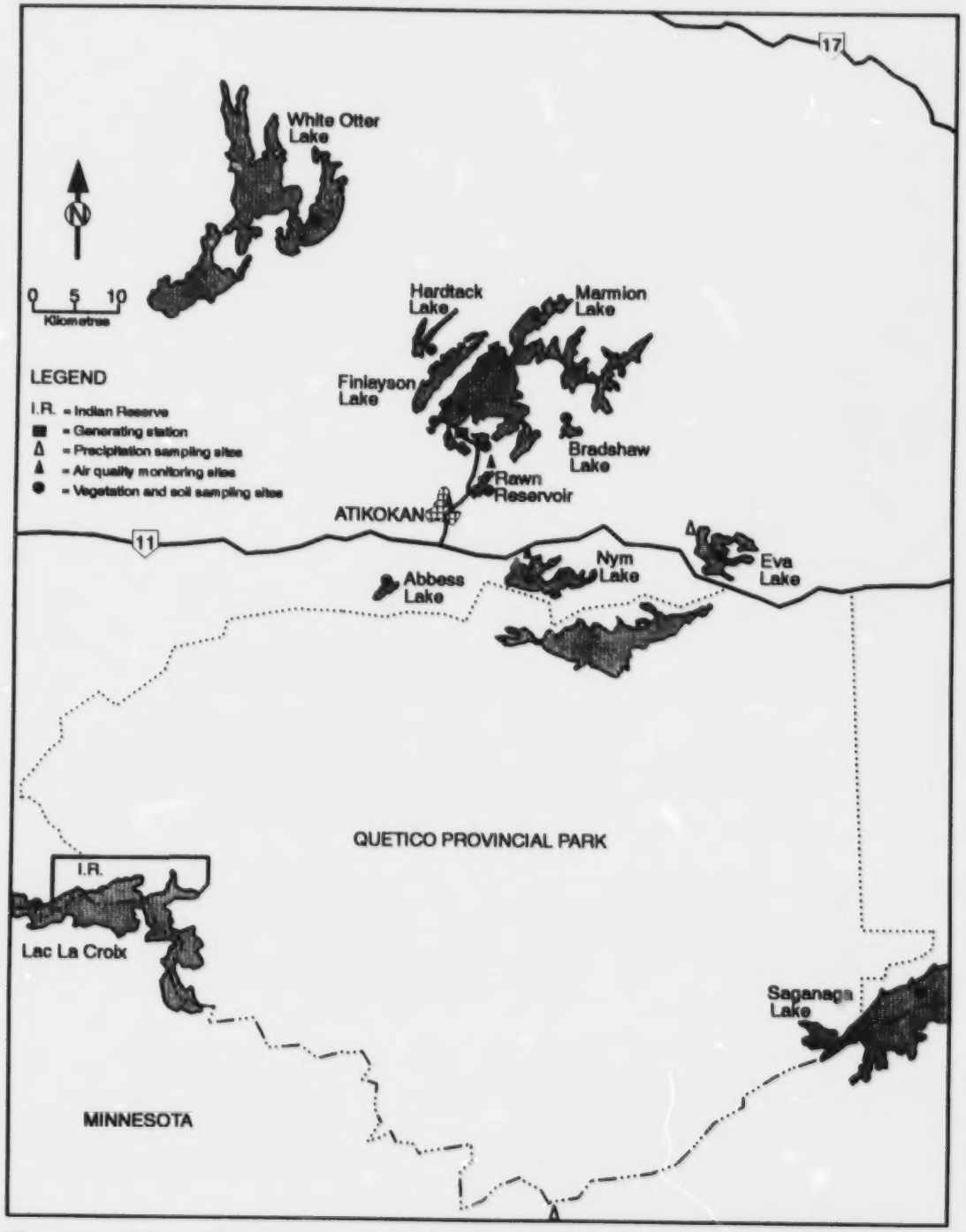


Figure 1. Air quality assessment sites, Ontario Hydro generating station, Atikokan, 1990.

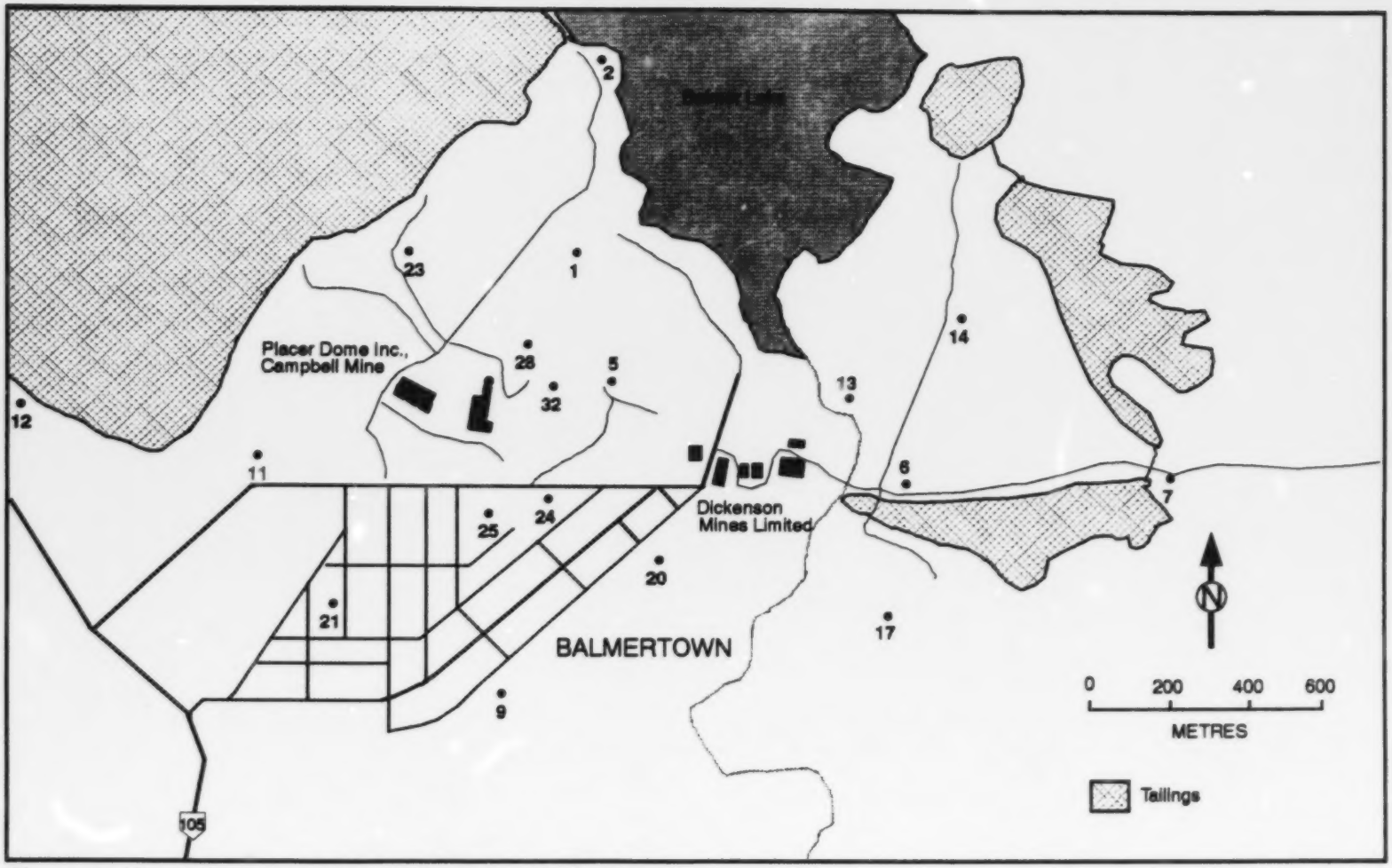


Figure 2. Trembling aspen sampling sites, Balmertown.

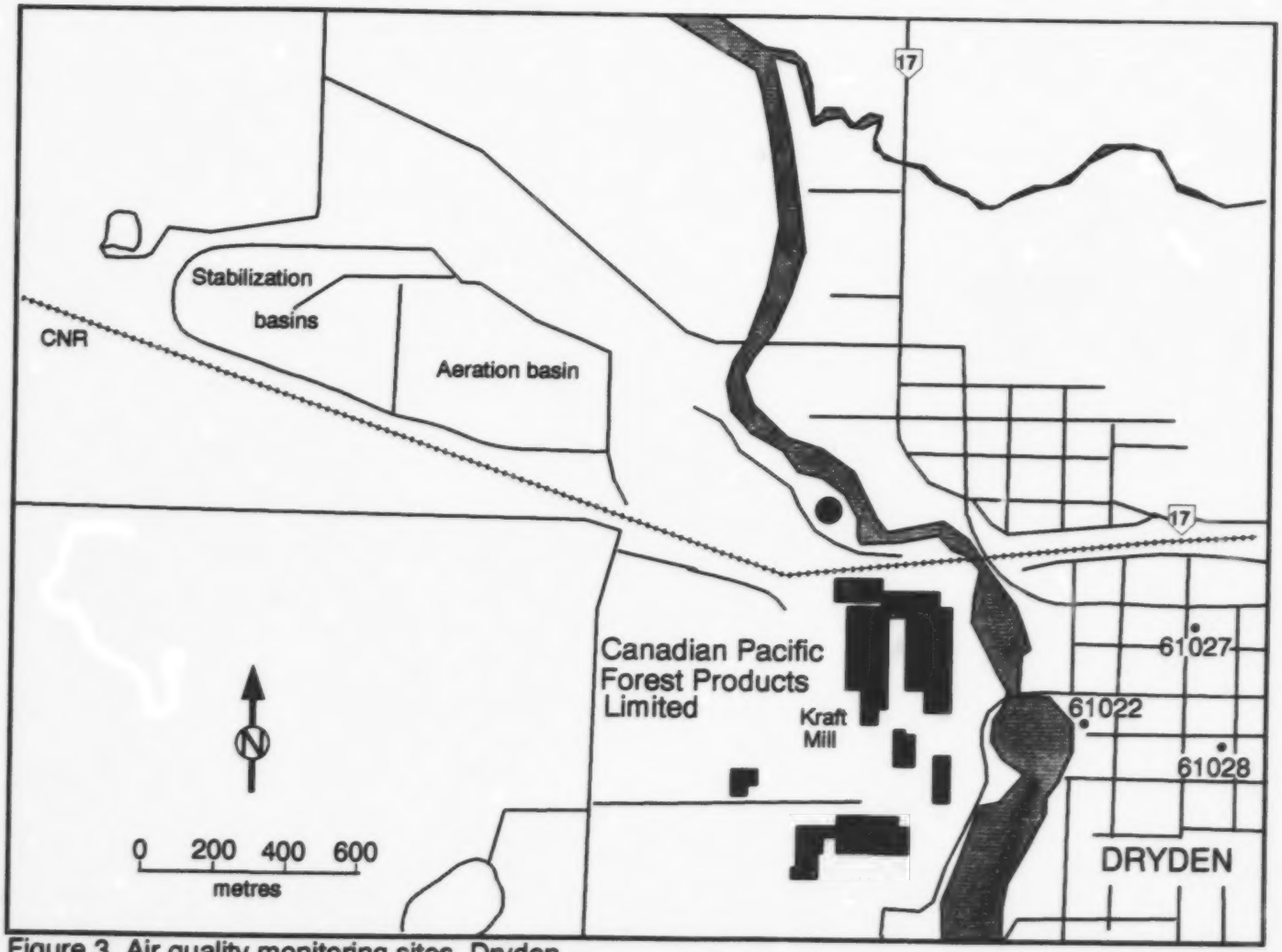


Figure 3. Air quality monitoring sites, Dryden.

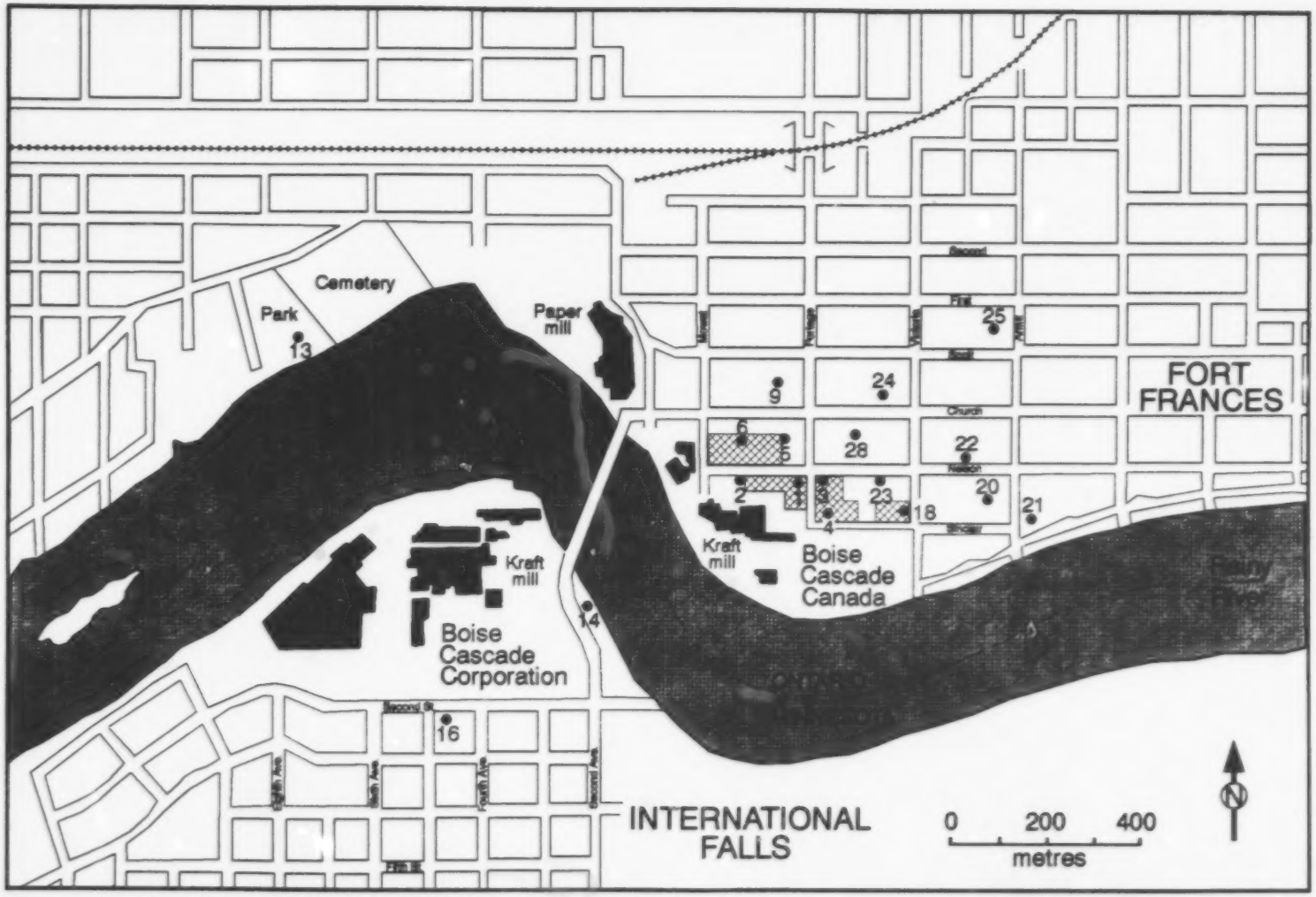


Figure 4. Manitoba maple sampling sites, Fort Frances.

Buffer zone

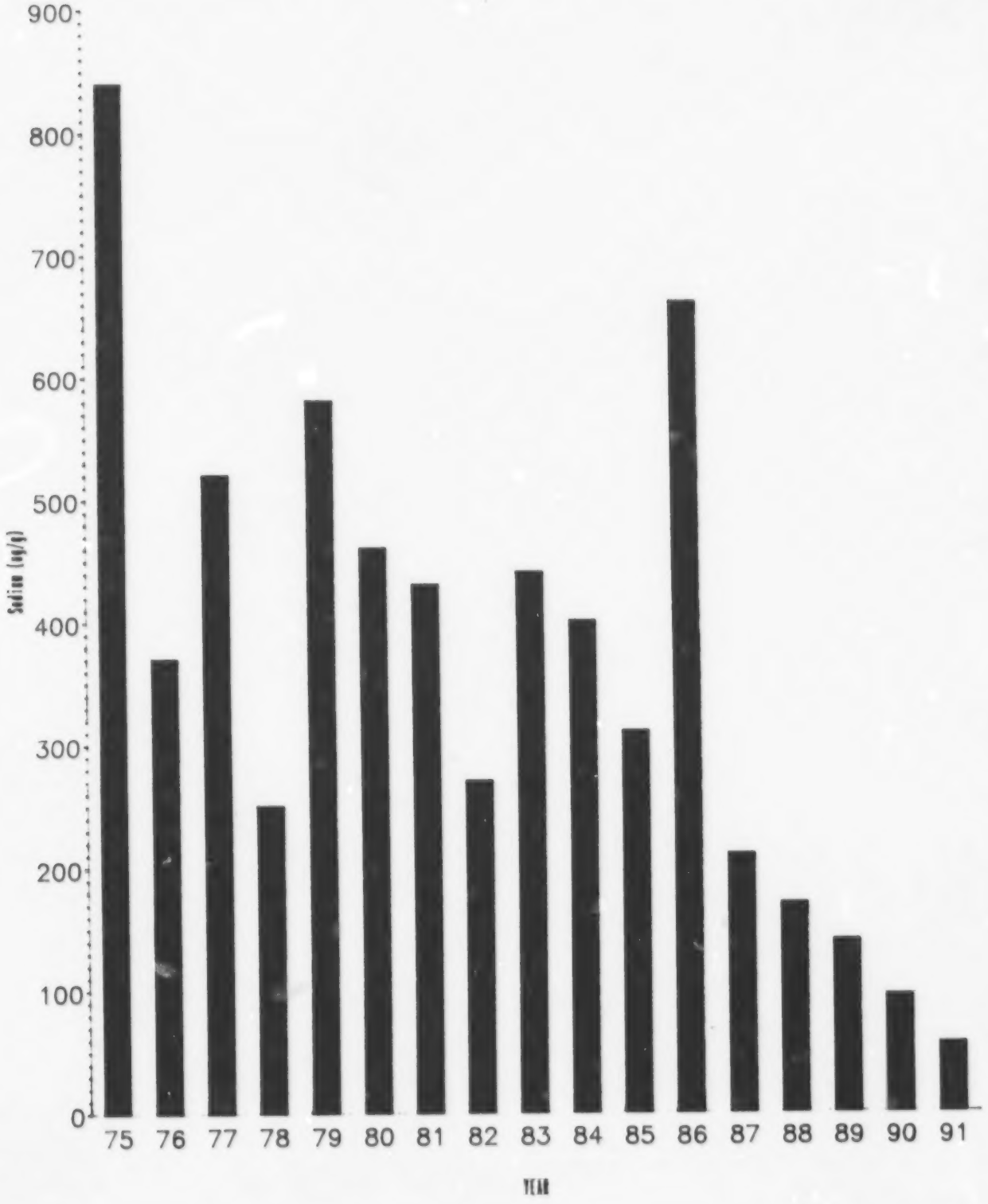


Figure 5. Average sodium (ug/g, dry weight) in Manitoba maple (Acer negundo) foliage, Fort Frances–International Falls, 1975–1991.

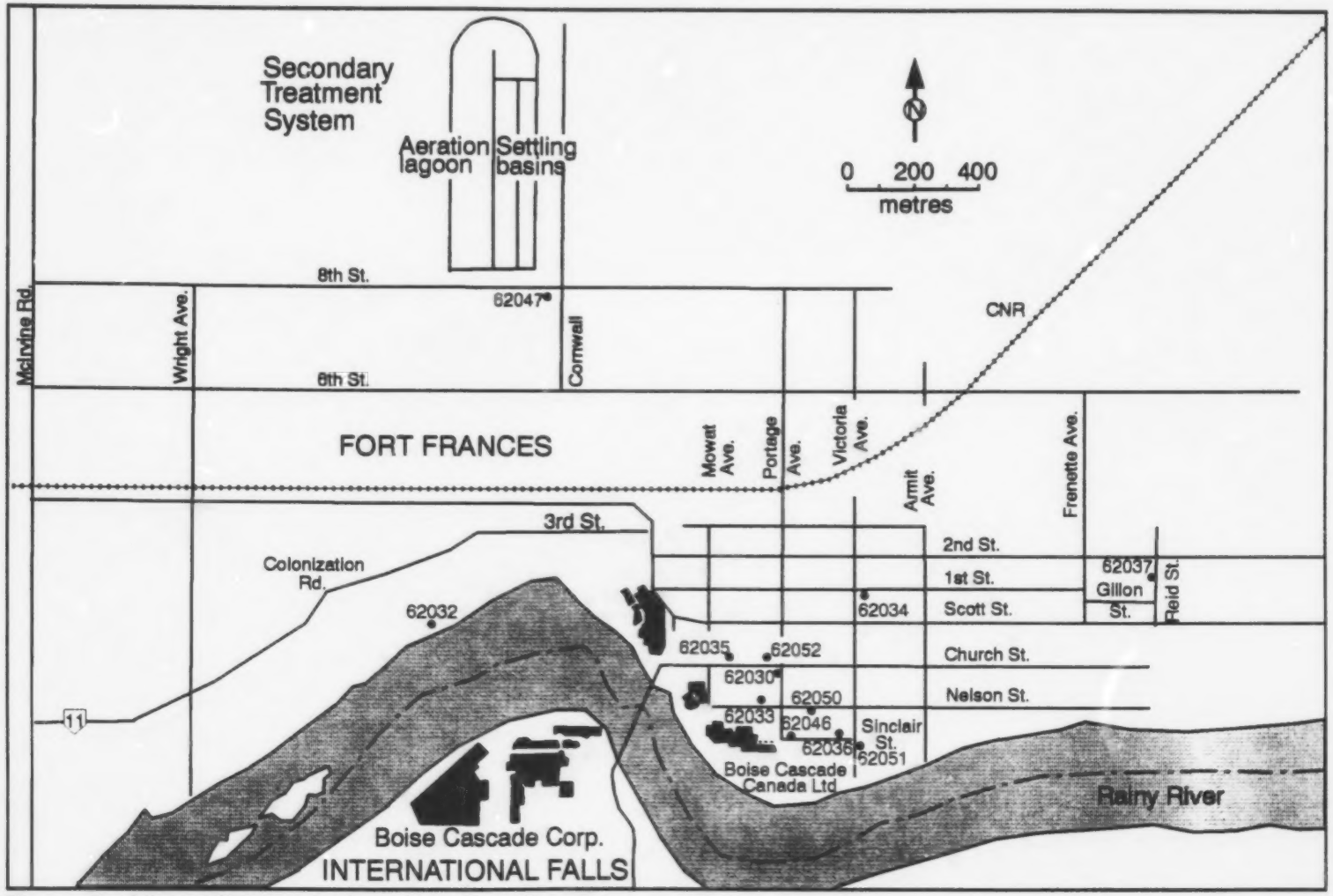


Figure 6. Air quality monitoring sites, Fort Frances.

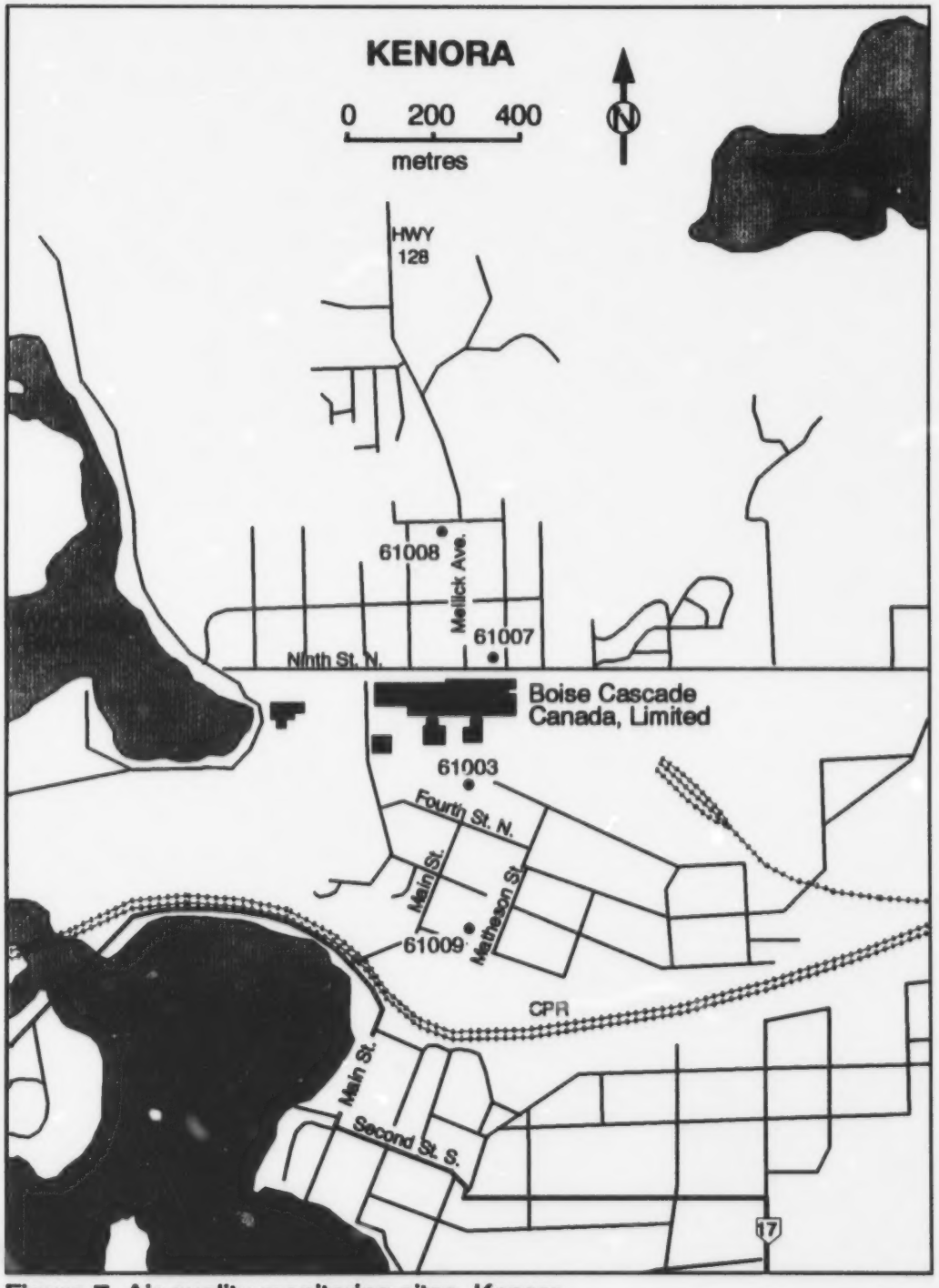


Figure 7. Air quality monitoring sites. Kenora.

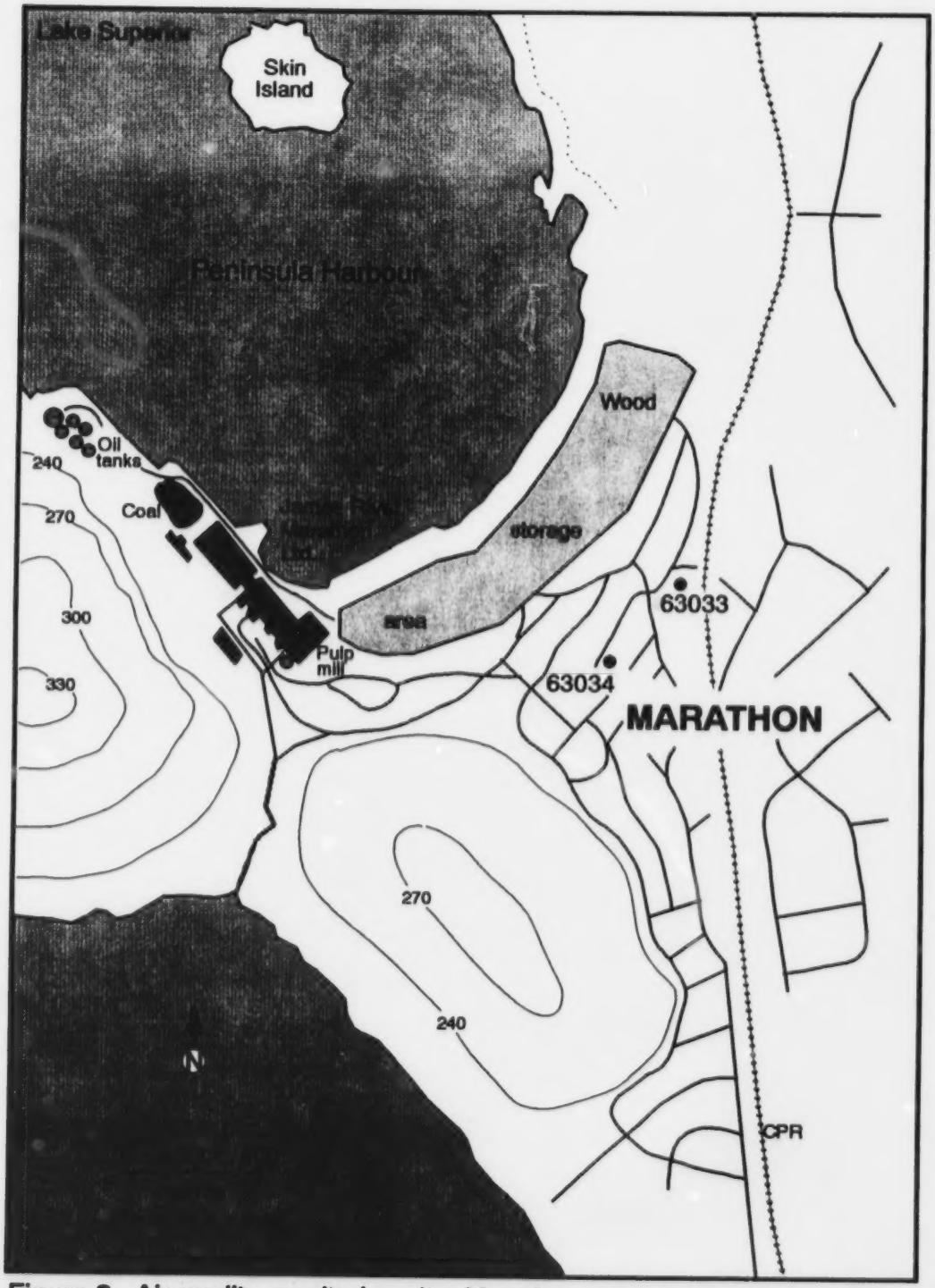


Figure 8. Air quality monitoring site, Marathon (relocated from 63034 to 63033 in February, 1991).

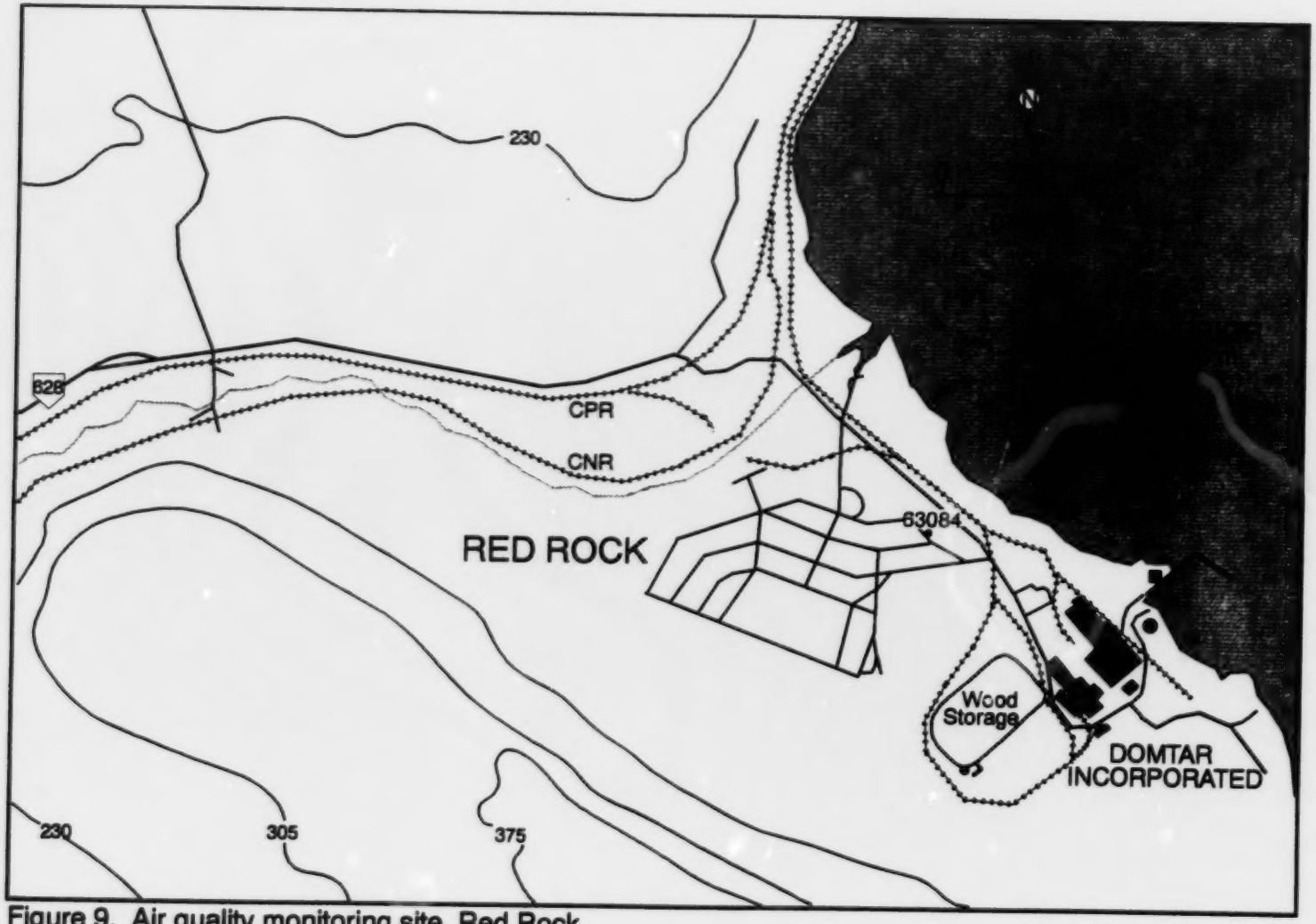


Figure 9. Air quality monitoring site, Red Rock.

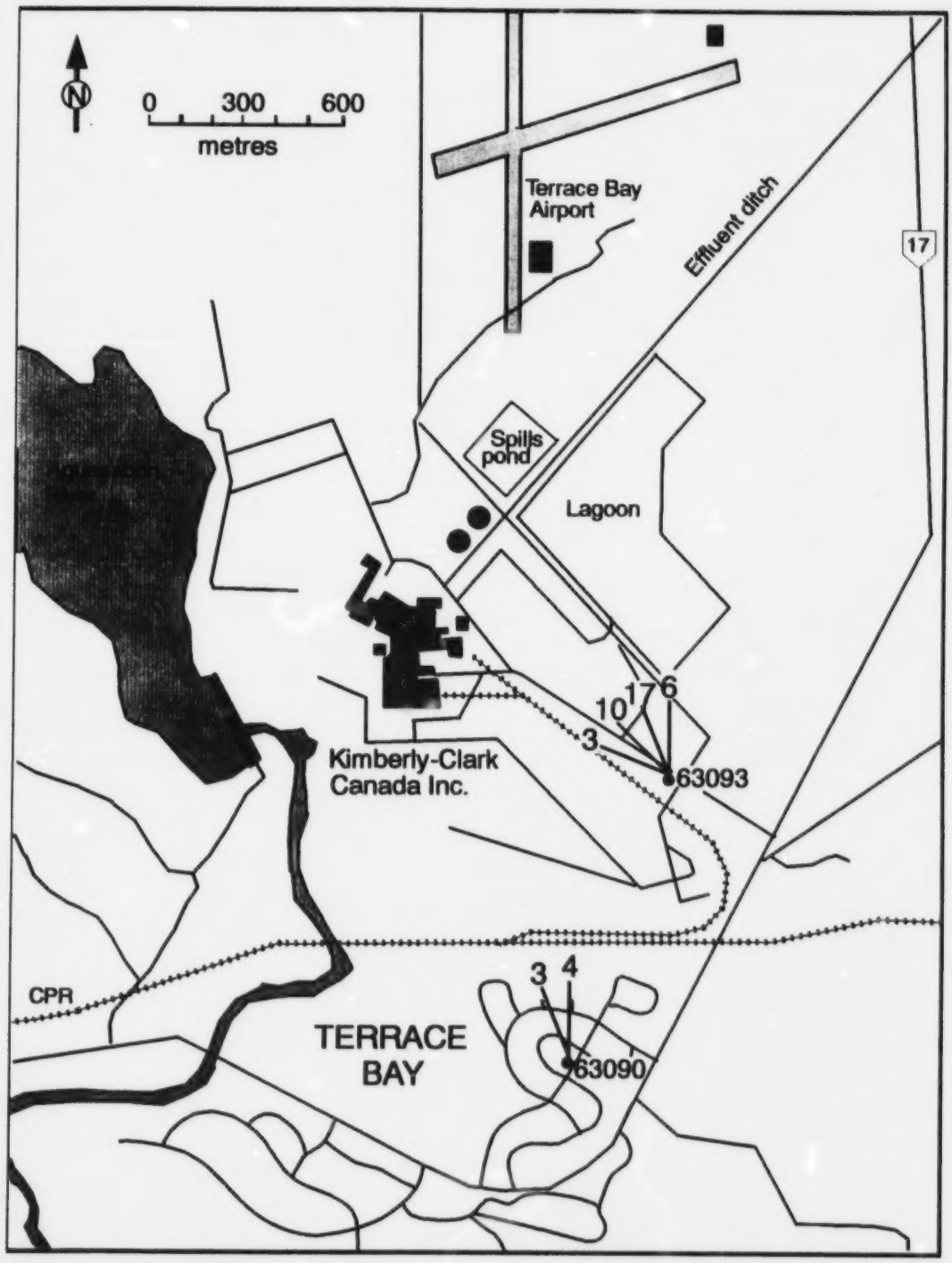


Figure 10. Air quality monitoring stations, Terrace Bay (average TRS levels (ppb) for 1991 shown for different wind directions at two monitoring sites).

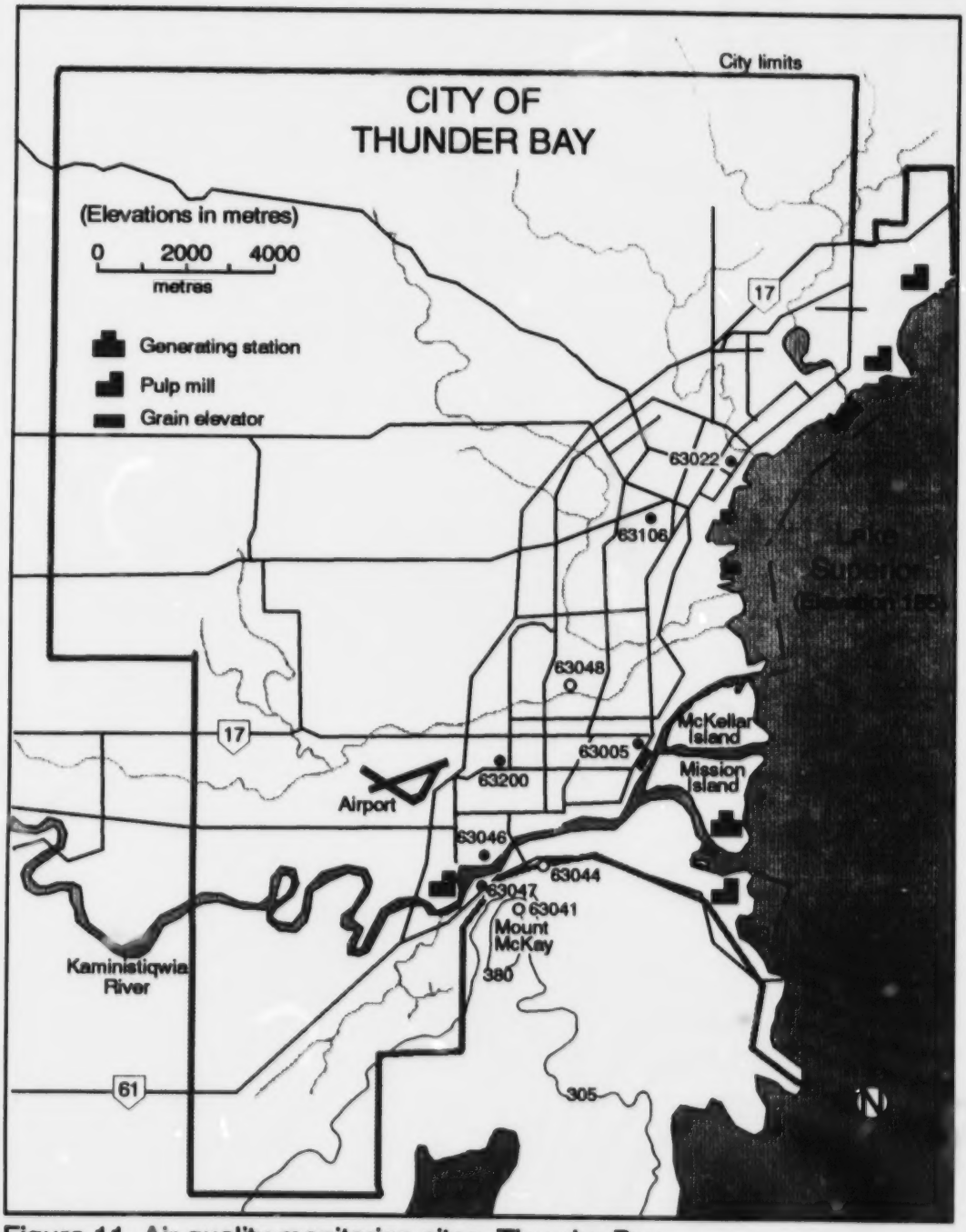


Figure 11. Air quality monitoring sites, Thunder Bay.
(o Ontario Hydro sites)

TABLE 1. Air quality monitoring network, Kenora District, 1991.

| Location | Station number | Parameters: Continuously monitored | | | | | | | | | Non-continuously monitored | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $SO_2$ | COH | CO | $O_3$ | $NO_2$ | TRS | Wind | Temp | AQI | TSP | PM10 | PAH | VOC | Dioxin | Dustfall |
| **BALMERTOWN** | | | | | | | | | | | | | | | | |
| Sewage Plant | 61014 | X | | | | | | | | | | | | | | |
| **DRYDEN** | | | | | | | | | | | | | | | | |
| 35 Van Horne Ave. | 61027 | | | | | | X | X | | | | | | | | |
| Earl/Albert | 61022 | | | | | | | | | | | | | | | X |
| Albert/Kirkpatrick | 61028 | | | | | | | | | | | | | | | X |
| **FORT FRANCES** | | | | | | | | | | | | | | | | |
| Portage/Church | 62030 | | X | | | | X | | | X | | | | | | |
| Cemetery | 62032 | | | | | | X | | | | X | | | | | X |
| Nelson/Portage | 62033 | | | | | | | | | | | | | | | X |
| First/Victoria | 62034 | | | | | | | | | | | | | | | X |
| Legion | 62035 | | | | | | | | | | | | | | | X |
| Sinclair/Victoria | 62036 | | | | | | | | | | | | | | | X |
| Reid/Gillon | 62037 | | | | | | | | | | | | | | | X |
| 308 Sinclair St. | 62046 | | | | | | | | | | | | | | | X |
| Eighth Street | 62047 | | | | | | X | X | | | | | | | | X |
| 319 Nelson Street | 62050 | | | | | | | | | | | | | | | X |
| Hospital | 62051 | | | | | | X | | | | | | | | | X |
| 427 Mowat Avenue | 62053 | | | | | | | X | | | | | | | | |
| **KENORA** | | | | | | | | | | | | | | | | |
| Fourth/Main | 61003 | | | | | | | | | | | | | | | X |
| Mellick/Ninth | 61007 | | | | | | | | | | | | | | | X |
| Mellick/Eleventh | 61008 | | | | | | | | | | | | | | | X |
| Third Street | 61009 | | | | | | | | | | | | | | | X |

TABLE 2. Air quality monitoring network, Thunder Bay District, 1991.

| Location | Station number | Parameters: Continuously monitored $SO_2$ | COH | CO | $O_3$ | $NO_2$ | TRS | Wind | Temp | AQI | Non-continuously monitored TSP | PM10 | PAH | VOC | Dioxin | Dustfall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ELY, MINNESOTA** | | | | | | | | | | | | | | | | |
| Fernberg Road | 62068 | | | X | | | | | | | | | | | | |
| **HAWKEYE LAKE** | 63100 | | | X | | | | | | | | | | | | |
| **MARATHON** | | | | | | | | | | | | | | | | |
| CPR Station | 63033 | | | | | | X | X | | | | | | | | |
| **RED ROCK** | | | | | | | | | | | | | | | | |
| Rec Centre | 63084 | | | | | | X | X | | | | | | | | |
| **SCHREIBER** | | | | | | | | | | | | | | | | |
| Highway 17 | 63400 | | | | | | | | | | X[a] | | | | | |
| 101 Manitoba St. | 63401 | | | | | | | | | | X[a] | | | | | |
| Public School | 63402 | | | | | | | X | | | | | | | | |
| **TERRACE BAY** | | | | | | | | | | | | | | | | |
| St. Martin's School | 63090 | | | | | | X | X | | | | | | | | |
| Masonic Temple | 63093 | | | | | | X | | | | | | | | | |
| **THUNDER BAY** | | | | | | | | | | | | | | | | |
| McKellar Hospital | 63005 | | | | | | | | | | X[b,c] | | | | | |
| St. Joseph's Hospital | 63022 | | | | | | | | | | X[b,c] | | | | | X |
| Can-Car | 63046 | | | X | | | X | | | | X | | | | | X |
| Totem Trailer Court | 63047 | | | | | | | | | | | | X | | | |
| Ray Boulevard | 63106 | | | | | | | | | | | | | X | | |
| James/Walsh | 63200 | X | X | X | X | X | X | X | | X | X[c,d] | X | | | | |

[a] Filters analyzed for cadmium, copper, iron and zinc.
[b] Filters analyzed for nitrate, sulphate and lead.
[c] Filters analyzed for nitrate and sulphate.
[d] Filters analyzed for lead.

TABLE 3. Arsenic content (µg/g, dry weight) of trembling aspen foliage, Balmertown, 1987-91.

| Site[a] | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|
| 1 | 19 | 6 | 7 | 9 | 5 |
| 2 | 52 | 9 | 8 | 15 | 5 |
| 5 | 24 | 13 | 10 | 12 | 13 |
| 6 | 15 | 24 | 9 | 33 | 21 |
| 7 | 4 | 3 | 2 | 3 | 4 |
| 9[c] | 7 | 5 | 4 | 4 | 4 |
| 11 | 11 | 7 | 9 | 22 | 16 |
| 12[c] | 5 | 3 | 2 | 4 | 6 |
| 13 | 140 | 230 | 36 | 440 | 73 |
| 14 | 20 | 42 | 6 | 29 | 14 |
| 17 | 11 | 17 | 10 | 5 | 8 |
| 20[c] | 11 | 7 | 5 | 4 | 3 |
| 21[c] | 6 | 4 | 6 | 4 | 3 |
| 23 | <1 | 7 | 9 | 48 | 8 |
| 24[c] | 18 | 5 | 7 | | |
| 25[c] | | | | 12 | 14 |
| 28 | 150 | 33 | 36 | 38 | 14 |
| 32 | 61 | 36 | 17 | 16 | 41 |
| Controls | <1 | <1 | <1 | <1 | <1 |

[a]Shown in Figure 2.
[b]Values above guideline (2 µg/g) are underlined.
[c]Sites in townsite area.

TABLE 4. Average arsenic content (µg/g, dry weight) of foliage from planted roadside Manitoba maple (Acer negundo) and white elm (Ulmus americana) trees, Balmertown, 1987-91.

| Site | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|
| Dickenson & Mine Rd. | 18 | 18 | 18 | 13 | 7 |
| Balmertown public school | 14 | 8 | 8 | 8 | 5 |
| Fifth St. & Mine Rd. | 10 | 7 | 12 | 20 | 8 |
| Control (Red Lake) | <1 | <1 | <1 | 1 | <1 |

TABLE 5. Summary of sulphur dioxide data, Balmertown, 1987-91.

| Year | Days of data | Annual ave. (ppm) | Annual exceedences | | Growing season exceedences | |
|---|---|---|---|---|---|---|
| | | | Hours | Days | Hours | Days |
| 1987 | 332 | 0.010 | 87 | 7 | 23 | 1 |
| 1988 | 353 | 0.008 | 53 | 2 | 19 | 0 |
| 1989 | 334 | 0.010 | 86 | 3 | 34 | 2 |
| 1990 | 364 | 0.007 | 63 | 5 | 34 | 2 |
| 1991[a] | 274 | 0.004 | 33 | 2 | 3 | 0 |

[a] January 1 to October 2

TABLE 6. Summary of concentrations (ppb) of total reduced sulphur, Dryden, 1987-91.

| Year | Days of data | Annual average | Maximum 1-hour average | Number of hours above guideline |
|---|---|---|---|---|
| 1987 | 346 | 0.5 | 26 | 0 |
| 1988 | 323 | 0.4 | 45 | 1 |
| 1989 | 362 | 0.4 | 20 | 0 |
| 1990 | 356 | 0.4 | 51 | 3 |
| 1991 | 365 | 0.3 | 21 | 0 |

TABLE 7. Average sodium concentrations in unwashed Manitoba maple foliage, Fort Frances-International Falls, 1980, 1987, 1989 and 1991.

| Site[a] | 1980 | 1987 | 1989 | 1991 |
|---|---|---|---|---|
| 1[b] | 1800[d] | 390 | 250 | 140 |
| 2[b] | 1400 | 290 | 180 | 87 |
| 3[b] | 1200 | 230 | 110 | 85 |
| 4[b] | 620 | 110 | 170 | 81 |
| 5 | 260 | 100 | 120 | 47 |
| 6 | 390 | 300 | 250 | |
| 9 | 150 | 240 | 110 | |
| 13 | 83 | 140 | 60 | 24 |
| 14[c] | 53 | 180 | 130 | 53 |
| 16[c] | 73 | 150 | 130 | 44 |
| 18 | 120 | 220 | 130 | 42 |
| 20 | 250 | 370 | 90 | 30 |
| 21 | 250 | 200 | 90 | 26 |
| 22 | 140 | 430 | 95 | 36 |
| 23 | 280 | 140 | 95 | 60 |
| 24 | 210 | 65 | 210 | |
| 25 | 410 | 160 | 120 | 48 |
| 28 | | 85 | 230 | 37 |
| Average, all sites | 460 | 210 | 140 | 56 |
| Controls | 100 | 38 | 68 | 22 |

[a]See Figure 4 for site locations.
[b]Sites on Boise Cascade Canada property.
[c]U.S. sites.
[d]Values above contaminant guideline (350 µg/g) are underlined.

TABLE 8. Average annual dustfall ($g/m^2/30$ d), Fort Frances, 1991.

| Monitoring sites[a] | Total dustfall | Insoluble dustfall |
|---|---|---|
| 62032 | 3.8 | 2.3 |
| 62033[b] | 6.9[c] | 4.2 |
| 62034 | 2.7 | 1.5 |
| 62035 | 2.9 | 2.2 |
| 62036 | 6.4 | 4.6 |
| 62037 | 2.8 | 1.1 |
| 62046[b] | 7.3 | 5.1 |
| 62050 | 5.4 | 2.8 |
| Average, sites off mill property | 4.2 | 2.4 |
| % of total dustfall, off-property sites | | 57 |

[a]See Figure 6.
[b]Sites on company property.
[c]Values above the maximum acceptable limit (4.6 $g/m^2/30$ d) are underlined.

TABLE 9. Average annual dustfall ($g/m^2/30$ d) at six Fort Frances monitoring sites[a] off mill property, 1986-91.

| Parameter | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|
| Total dustfall | 7.1 | 5.9 | 6.1 | 5.1 | 4.8 | 4.2 |
| Insoluble dustfall | 3.8 | 3.1 | 3.6 | 3.0 | 2.9 | 2.4 |
| Saltcake in dustfall | 1.4 | 1.1 | 0.9 | NA[b] | 0.3 | 0.3 |

[a]Stations 62030/35, 62032, 62034, 62036, 62037, and 62050.
[b]Not available for 1989.

TABLE 10. Summary of total reduced sulphur concentrations (ppb) at stations 62030, 62052 and 62032, Fort Frances, 1976-1991.

| Year | Days of data | Annual average | Maximum 1-hour average | Number of hours above guideline |
|---|---|---|---|---|
| | | Station 62030/62052 | | |
| 1976[a] | 309 | 12.8 | 458 | 916 |
| 1977[a] | 294 | 15.4 | 480 | 969 |
| 1978[a] | 304 | 16.1 | 540 | 1035 |
| 1979[a] | 344 | 10.2 | 353 | 911 |
| 1980[a] | 352 | 9.3 | 499 | 872 |
| 1981[a] | 277 | 12.0 | 279 | 806 |
| 1982[a] | 320 | 8.8 | 543 | 685 |
| 1983[b] | 336 | 4.9 | 254 | 418 |
| 1984[b] | 332 | 2.8 | 98 | 135 |
| 1985[b] | 363 | 2.0 | 191 | 87 |
| 1986[a,b] | 335 | 3.9 | 226 | 300 |
| 1987[a] | 359 | 5.5 | 278 | 431 |
| 1988[a,b] | 359 | 5.9 | 268 | 552 |
| 1989[a,b] | 365 | 5.0 | 126 | 414 |
| 1990[a] | 360 | 5.5 | 159 | 493 |
| 1991[a] | 365 | 4.3 | 235 | 251 |
| | | Station 62032 | | |
| 1976 | 139 | 2.5 | 116 | 91 |
| 1977 | 225 | 3.3 | 129 | 176 |
| 1978 | 281 | 2.5 | 134 | 141 |
| 1979 | 306 | 2.9 | 140 | 178 |
| 1980 | 307 | 3.3 | 124 | 210 |
| 1981 | 271 | 3.1 | 211 | 202 |
| 1982 | 269 | 2.1 | 99 | 115 |
| 1983 | 309 | 2.8 | 87 | 180 |
| 1984 | 314 | 1.9 | 74 | 38 |
| 1985 | 363 | 1.1 | 61 | 28 |
| 1986 | 325 | 1.2 | 133 | 37 |
| 1987 | 345 | 1.8 | 215 | 61 |
| 1988 | 363 | 1.7 | 160 | 84 |
| 1989 | 331 | 1.4 | 262 | 61 |
| 1990 | 365 | 1.2 | 85 | 43 |
| 1991 | 365 | 1.9 | 99 | 158 |

[a]Station 62030
[b]Station 62052

TABLE 11. Summary of total reduced sulphur concentrations (ppb) at stations 62047(lagoon) and 62051 (hospital), Fort Frances, 1990-91.

| Year | Days of data | Annual average | Maximum 1-hour average | Number of hours above guideline |
|---|---|---|---|---|
| | | Station 62047 | | |
| 1990 | 354 | 3.3 | 245 | 216 |
| 1991 | 363 | 3.0 | 235 | 171 |
| | | Station 62051 | | |
| 1990 | 325 | 2.1 | 104 | 56 |
| 1991 | 352 | 1.4 | 62 | 41 |

TABLE 12. Summary of TRS concentrations (ppb) at stations 63034 and 63033, Marathon, 1987-91.

| Year | Days of data | Annual average | Maximum 1-hour average | Number of hours above guideline |
|---|---|---|---|---|
| 1987 | 331 | 2.0 | 150 | 93 |
| 1988 | 327 | 2.2 | 67 | 109 |
| 1989 | 365 | 1.5 | 175 | 54 |
| 1990 | 351 | 1.1 | 101 | 21 |
| 1991[a] | 364 | 0.8 | 81 | 24 |

[a]Monitoring site relocated on February 27 from station 63034 to 63033

TABLE 13. Summary of TRS concentrations (ppb) at station 63084, Red Rock, 1987-91.

| Year | Days of data | Annual average | Maximum 1-hour average | Number of hours above guideline |
|---|---|---|---|---|
| 1987 | 337 | 3.1 | 216 | 203 |
| 1988 | 350 | 2.8 | 201 | 173 |
| 1989 | 296 | 1.4 | 77 | 44 |
| 1990 | 344 | 1.6 | 83 | 80 |
| 1991 | 349 | 1.4 | 62 | 42 |

TABLE 14. Summary of TRS concentrations (ppb) at stations 63090 and 63093, Terrace Bay, 1987-91.

| Years | Days of data | Annual average | Maximum 1-hour average | Number of hours above guideline |
|---|---|---|---|---|
| | | Station 63090 | | |
| 1987 | 316 | 2.4 | 159 | 121 |
| 1988 | 332 | 2.2 | 129 | 111 |
| 1989 | 342 | 1.4 | 95 | 64 |
| 1990 | 365 | 1.3 | 65 | 51 |
| 1991 | 365 | 1.3 | 62 | 59 |
| | | Station 63093 | | |
| 1989 | 344 | 4.4 | 180 | 373 |
| 1990 | 351 | 2.7 | 381 | 204 |
| 1991 | 360 | 4.4 | 236 | 379 |

TABLE 15. Total dustfall ($g/m^2/30$ d), Thunder Bay, 1991.

| Station[a] | Location | Monthly Min | Monthly Max | Annual average |
|---|---|---|---|---|
| 63046 | Montreal Street | 1.2 | 4.1 | 2.5 |
| 63047 | Totem Trailer Court | 1.1 | 6.6 | 3.7 |

[a]See Figure 11.

TABLE 16. Total suspended particulate matter ($\mu g/m^3$), Thunder Bay, 1991.

| Station[a] | Number of samples | Annual geometric mean | Number of samples above 120 $\mu g/m^3$ | Maximum 24-hour value |
|---|---|---|---|---|
| 63005 | 57 | 33 | 0 | 100 |
| 63022 | 53 | 28 | 0 | 120 |
| 63046 | 59 | 40 | 0 | 103 |
| 63200 | 58 | 38 | 0 | 112 |

[a]See Figure 11.

TABLE 17. Summary of carbon monoxide, nitrogen dioxide and ozone concentrations (ppm) in Thunder Bay, ozone at Hawkeye Lake, and ozone at Ely, Minnesota.

| | Station | Maximum 1-hour average | Maximum 8 hour average | Maximum 24-hour average |
|---|---|---|---|---|
| Carbon monoxide | 63046 | 5.0 | 2.2 | |
| Carbon monoxide | 63200 | 10.0 | 3.1 | |
| Nitrogen dioxide | 63200 | 0.07 | | 0.05 |
| Ozone, Thunder Bay | 63200 | 0.074 | | |
| Ozone, Hawkeye Lake[a] | 63100 | 0.079 | | |
| Ozone, Ely, Minnesota | 62068 | 0.084 | | |

[a]40 km north-northwest of Thunder Bay.

TABLE 18. Summary of sulphur dioxide concentrations (ppm) in Thunder Bay, 1991.

| Station[a] | Location | Annual average | Maximum 1-hour average | Maximum 24-hour average |
|---|---|---|---|---|
| 63200 | 615 S. James Street | <0.001 | 0.04 | 0.01 |
| 63041[b] | Mt. McKay | | 0.29 | 0.02 |
| 63042[b] | East End | | 0.03 | <0.01 |
| 63044[b] | James St./Kam River | | 0.05 | <0.01 |
| 63048[b] | Ford Street | | 0.03 | <0.01 |
| 63049[b] | Chippewa Park | | 0.06 | 0.01 |

[a]See Figure 11 for station locations.
[b]Ontario Hydro. Air Quality Compliance Reports, 1991. Thermal Integration and Services Division, Environmental Support Department. (Station 63042 was shut down April 30, and station 63049 ceased operating on June 30.)

TABLE 19. Summary of total reduced sulphur concentrations (ppb), station 63046[a], Thunder Bay, 1986-90.

| Year | Days of data | Annual average | Maximum 1-hour average | Number of times above guideline |
|---|---|---|---|---|
| 1987 | 329 | 0.8 | 52 | 12 |
| 1988 | 361 | 1.0 | 36 | 5 |
| 1989 | 343 | 1.0 | 51 | 2 |
| 1990 | 354 | 1.0 | 40 | 16 |
| 1991 | 362 | 1.2 | 60 | 19 |

[a]See Figure 11 for station location.